ATSS6 JUN 16 1964

National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-2078

ST - AA - 10154

No ACC

Consultants and Designers, Inc., Arlington, Va.

THE SPECTRAL COMPOSITION OF THE NIGHT SKY GLOW EMISSION IN A CONTINUOUS SPECTRUM AND PHOTOELECTRIC OBSERVATIONS OF INTENSITY VARIATIONS OF [OI] 5577 AND NaD EMISSIONS

by
V. M. Morozov

[USSR]

12 JUNE 1964 16 P

DRAFT TRANSLATION ST - AA - 10154

THE SPECTRAL COMPOSITION OF THE NIGHT SKY GLOW EMISSION IN A CONTINUOUS SPECTRUM AND PHOTOELECTRIC OBSERVATIONS OF INTENSITY VARIATIONS OF [01] 5577 AND NaD EMISSIONS *

Izvestiya A. N. SSSR,
seriya geofizicheskaya,
No. 4, pp. 604 - 614,
Izd-vo "NAUKA", 1964.

by V. M. Morozov

SUMMARY

Considered in this paper are the latest experimental data on the spectral composition of the night sky airglow emission in a continuous spectrum and the several sources of errors in photoelectric observations of emissions [01] 5577 and NaD intensity variations. It is shown that the errors that may be linked with the inconstancy of emission's spectral composition in a continuous spectrum, exert no significant effect on the variations of emissions' [01] 5577 and 5893 A NaD intensities registered during photoelectric observations.

* * *

1. - The intensity of night sky emission in a continuous spectrum varies within broad limits [1 — 3]. These variations are usually ascribed to the radiation occurring in the high layers of the Earth's atmosphere. According to observations near Zvenigorod ($\varphi_N = 55°43'; \lambda_E = 36°46'$) during the IGY and the IGC, the intensity of the night sky emission in the pole region varied at 5280 A from the minimum value of 0.94 rayleighs $\cdot$ A^{-1} to the maximum of 4.6 rayleighs $\cdot$ A^{-1}. Thus, the aggregate intensity of the continuous emissions exceeded by 3 — 15 times the stellar background intensity in the polar region, and

* [O SPEKTRAL'NOM SOSTAVE IZLUCHENIYA NOCHNOGO NEBA V NEPRERYVNOM SPEKTRE I FOTOELEKTRICHESKIKH NABLYUDENIYAKH VARIATSIY INTENSIVNOSTEY EMISSIY [01] 5577 I NaD]

constituted in the visible region of the spectrum (4300 — 6300 Å) from about 200 to 9000 rayleighs. The intensity of the [01] 5577 emission during that time period varied within the limits from 50 to 670 rayl. and the emission NaD intensity —from 16 to 300 rayleighs (in band).

When investigating spectrographically the distribution of intensities in a continuous spectrum of night sky emission, certain difficulties arise in connection with the necessity of separating the emission in bands with an insufficiently resolved structure, and of taking into account of the presence of absorption lines of stellar background. In connection with that the processing method, based on the utilization of continuum variation with time, deserves attention. Comparing the photoelectric measurements of night sky glow near 5700 Å where the emission in OH bands (6.0) is quite small, with measurements in other portions of the spectrum, one may determine directly the spectral composition by the variable emission component in the continuous spectrum, provided the complementary emissions (in lines and even in the continuous spectrum) do not correlate with the basic variable emission component in the continuous spsectrum. This statistical method of analysis was utilized in the works [2 — 5].

According to measurements at two points of the sky, it is possible to exclude the intensity of the terrestrial component from the total intensity of night sky glow. Observations near Zvenigorod were conducted in the pole and zenith, i. e .at a distance of about 34^{o} from the pole. According to these measurements the variations δ_{λ} of the extra terrestiral component of the night sky glow, depending on stellar time could be separated in the zenith relative to extraterrestrial (constant) component in the pole in various portions of the spectrum, and to determine the spectral composition of these relative variations of the extraterrestrial component in the zenith (δ_{λ}) in each separate case. Compiled in Table 1 are the final results of determination of spectral composition of extra-terrestrial component's relative variations in the zenith (δ_λ) according to the results of Zvenigorod observations in 1959. The questions linked with the separation of the extraterrestrial component, will be examined at further length.*

T A B L E 1

Authors	Method and Place of Observation	Emission		Wavelength, Å						
				4300	5300	5577	5700	5900	6040	6300
[6]	Spectrograph. using 5 spectra Alma-Ata	Aggr.		0,99	1,00			1,04		1,06
[7 - 10]	Ibid. by 24 spectra Zvenigorod	Aggr.		0,6	1,00			1,02		0,96
[2]	Photoelectr. Provence	Terr,		0,95	1,00			0,779		0,818
V. M. Morozov	Photoelectr. Zvenigorod	Terr.	a)	0,94	1,00		1,00	1,05		
			б)	0,95	1,00		1,02	1,09		
		Extra-Terr.		1,24 ±0,03	1,00	1,07 ±0,07	0,94 ±0,02	0,96 ±0,05		0,90 ±0,17
[11, 12]	Photoelectr. Ashkhabad	Terr.			1,00		1,43		1,25	
		Extra-terrest.			1,00	1,25	1,17		1,08	

The results of determination of the mean spectral composition of the aggregate, extra-terrestrial and terrestrial emissions in a continuous spectrum, obtained by various authors and different methods only quite recently, are compiled in the above Table 1. The emission of a class-G2 star in continuous spectrum was taken as a unit in all parts of the spectrum. and expressed in quanta; besides, all data are combined near $\lambda = 5300$ Å.

The spectral composition of the aggregate night sky emission in a continuous spectrum is rather close to intensity distribution in the continuous emission of a class-G2 star, and we shall conditionally call it

* V. M. Morozov.- O nekotorykh osobennostyakh vnezemnoy i zemnoy sostavlyayushchikh svecheniya nochnogo neba.- Geomagnetizm i Aeronomiya, 4, No. 3, [in print] 1964

spectral distribution of type G2 intensities. An analogus conclusion can be derived on the spectral composition of terrestrial and extraterrestrial components by photoelectric observations in Zvenigorod. In the case of the extraterrestrial component, a substantial deflection is observed only near 4280 Å in [11]. This deflection from the spectral distribution of the type G2 is linked with the presence of one maximum in the atmosphere emission and of another one in the extraterrestrial emission. Both maxima are in the 5300 to 6000 Å spectrum region. Barbier and Glaume [2] have established, to the contrary, the presence of a certain small and smooth lowering of atmosphere emission intensity in a continuous spectrum of the region with $\lambda > 5300$ Å, by comparison with the type G2 intensity distribution.

2.- Usually, when observing the intensities of discrete emission near λ_i by photoelectric methods, the accounting of the intensity of the variable background is made by measurements near 5300 A ($\lambda_i \neq 5300$ Å) in the assumption that the intensity distribution in the background spectrum is constant and coincides with the spectral distribution of type G2 intensities. If the admitted intensity distribution in the background spectrum is systematically and distinctly different from the real one, this must lead to the appearance of a correlation between the discrete emission, computed that way, and the background, even in the cases when the link between the real discrete emission and the background is absent, and to the appearance of fictitious variations of discrete emission, when in reality it remains constant. According to [12], it is sufficient to admit for the stellar background ratio* the type-G2 distribution, in order that the intensity variations of the stellar background (measured at 5300 Å) lead to the appearance of fictitious seasonal and daily variations of the [OI) 5577 emission by amplitude and time of maxima appearance, similar to those which are obtained by photoelectric measurements at various stations. In essence, the Truttse deductions mean that in practice, nearly all the results of photoelectric observations of the night sky glow with the standard interferometer filters (whose volume has particularly significantly increased during IGY and IGC) cannot be considered reliable.

* I_{5557} / I_{5300},

3.- Let us examine the results of photoelectric measurements of night sky glow in Zvenigorod for the period from 7 August 1957 to 7 November 1959. The photometer's absolute calibration and its preservation are described in [13 — 15]. We shall point out only that the equivalent width of filtration $\Delta\lambda$ near $\lambda\lambda$ 5280, 4280, 5577, 5710, 5890 Å is respectively 130, 146, 176, 134, 123 Å as the average of two measurements. Let us directly denote the measured intensities near $\lambda\lambda$ 5280, 4280, 5577, 5710, 5890 Å, expressed in rayleighs, respectively by x, y, z, u, v.

Contrary to the analogous data of [5], we shall account only for all the simultaneous measurements in the zenith and at the pole (at the beginning of every hour), conducted during the nights, when according to visual and spectrographic observations, aurorae were absent. The intensities y, z, u, v, as functions of the intensity **x**, expressed in rayleighs, separately for autumn-winter and spring periods of observation, are plotted in Fig. 1, 2 for measurements at the zenith, and in Fig. 3, 4 for measurements at the pole (respectively Fig. 1, 3, I and Fig. 2, 4, II). The regression lines $\bar{y} = p_{yx}x + q_{yx}$, $\bar{z} = p_{zx}x + q_{zx}$, $\bar{u} = p_{ux}x + q_{ux}$, $\bar{v} = p_{vx}x + q_{vx}$, are in dashes and the solid lines respond to the conditions $q = 0$ and $p_{yx} = s$, $p_{zx} = f$, $p_{ux} = l$, $p_{vx} = m$, where the coefficients s, f, l, m are found in the assumption that the distribution of intensities in the continuous emission spectra of night sky glow of class G2 star coincide.

Data, related to autumn-winter observations at zenith and at the pole, are respectively included in the lines I Zenith and I Pole of Table 2, and those related to spring observations at the zenith and the pole — in the lines II Zenith and II Pole. The values of the correlations factors y, z, u, v with x, and of regression coefficients $p_{yx}, p_{zx}, p_{ux}, p_{vx}$. are included in Table 2. The deflections of these regression coefficients from the corresponding coefficients s, f, l, m (with their mean values in the last line) are also in Table 2, together with the mean values of intensities $\bar{y}, \bar{z}, \bar{u}, \bar{v}$, the standard deflections y, z, u, v relative to the corresponding regression lines $S_{yx}, S_{zx}, S_{ux}, S_{vx}$, the ratio of the latter to the corresponding mean values of intensities $S_{yx}/\bar{y}, S_{zx}/\bar{z}, S_{ux}/\bar{u}, S_{vx}/\bar{v}$ and the coefficients $q_{yx}, q_{zx}, q_{ux}, q_{vx}$.

The mean Zvenigorod data (a) and (b) on the spectral composition of terrestrial emission in a continuous spectrum (see Table 1) are found : a) by four values of p_{yx} (or respectively p_{ux}, p_{vx}), brought out in Table 1 in [5] and b) by four values of p_{yx} (or respectively p_{ux}, p_{vx}), brought in Table 2 of the current paper *.

TABLE 2

Observ. Groups	Number of Observat n	Emission y and x						
		$r_{yx} \pm \sigma_{r_{yx}}$	$p_{yx} \pm \sigma_{p_{yx}}$	$p_{yx} - s$	$\bar{y}$, релен	S_{yx}, релен	$S_{yx}/\bar{y}$	q_{yx}, релен rayleighs
I Zenith	152	0,894±0,016	0,868±0,036	0,048	231	15	0,064	25
I Pole	152	0,832±0,025	0,670±0,036	−0,150	188	16	0,083	54
II Zenith	121	0,920±0,014	0,761±0,030	−0,059	195	16	0,082	43
II Pole	121	0,931±0,012	0,775±0,028	−0,045	198	16	0,080	33
				−0,05				

Observ. Groups	Emissions z and x						
	$r_{zx} \pm \sigma_{r_{zx}}$	$p_{zx} \pm \sigma_{p_{zx}}$	$p_{zx} - f$	$\bar{z}$, релен	S_{zx}, релен	$S_{zx}/\bar{z}$	q_{zx}, релен rayleighs
I Zenith	0,469±0,063	1,76±0,27	0,42	635	112	0,18	217
I Pole	0,316±0,073	1,21±0,30	−0,13	633	128	0,20	391
II Zenith	0,880±0,021	2,23±0,11	0,88	454	60	0,13	6
II Pole	0,902±0,017	2,47±0,11	1,13	493	61	0,12	−30

Observ. Groups	Emissions u and x						
	$r_{ux} \pm \sigma_{r_{ux}}$	$p_{ux} \pm \sigma_{p_{ux}}$	$p_{ux} - l$	$\bar{u}$, релен	S_{ux}, релен	$S_{ux}/\bar{u}$	q_{ux}, релен rayleighs
I Zenith	0,805±0,029	1,051±0,063	0,011	309	26	0,085	60
I Pole	0,789±0,031	1,081±0,069	0,041	284	30	0,10	68
II Zenith	0,960±0,007	1,039±0,028	−0,001	240	15	0,063	32
II Pole	0,960±0,007	1,075±0,029	0,035	256	16	0,063	28
			0,02				

Observ. Groups	Emissions v and x.						
	$r_{vx} \pm \sigma_{r_{vx}}$	$p_{vx} \pm \sigma_{p_{vx}}$	$p_{vx} - m$	$\bar{v}$, релен	S_{vx}, релен	$S_{vx}/\bar{v}$	q_{vx}, релен rayleighs.
I Zenith	0,533±0,058	1,12±0,14	0,17	359	60	0,17	93
I Pole	0,467±0,064	1,04±0,16	0,09	345	69	0,20	137
II Zenith	0,786±0,035	0,899±0,065	−0,051	282	35	0,12	102
II Pole	0,793—0,034	1,102±0,077	0,152	306	44	0,14	73
			0,09				

* The Zvenigorod data are in all cases related to the emission registered from the sea level (ground), i. e. emission having passed the lower atmosphere layer. For the effect of light scattering in the real atmosphere on the observed luminance of night sky glow, see ref. [16].

4.- Conclusions

a) - The great deflections p_{zx} from f (Table 2), exceeding the standard errors σp_{zx} in the determination of regression coefficients by about one order, correspond to the earlier considered cases of appearance of emission [O1] 5577 correlation with that in the continuous spectrum. In some other cases the deflection type G2 intensity distribution

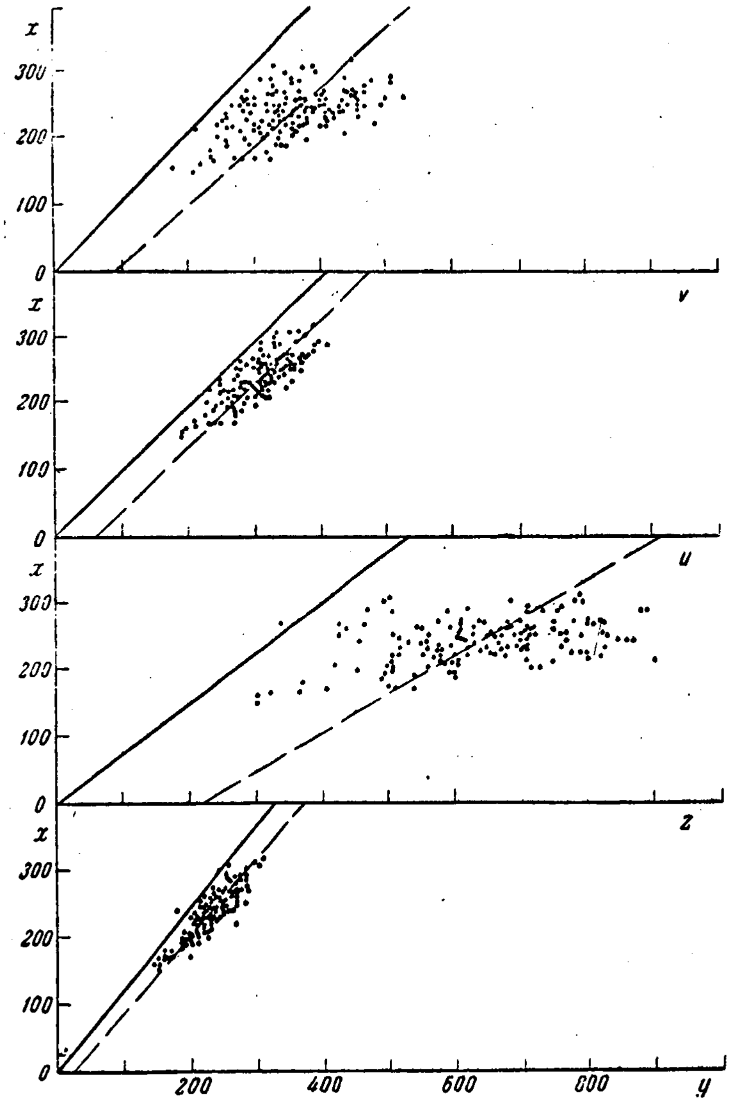

Fig. 1

(Table 2) also exceed the corresponding small standard errors σ_p in the determination of regression p coefficients, but then they remain relatively small (for example, for autumn-winter observation periods, I pole, $p_{yx}-s=-0.150$, $p_{y}^{x}=0.036$. In connection with that it should be noted that there are other errors, difficult to account for. Possible are errors linked with data nonuniformity. For instance, the difference $p_{yx}-s$, found according to 121 and 135 measurements during spring

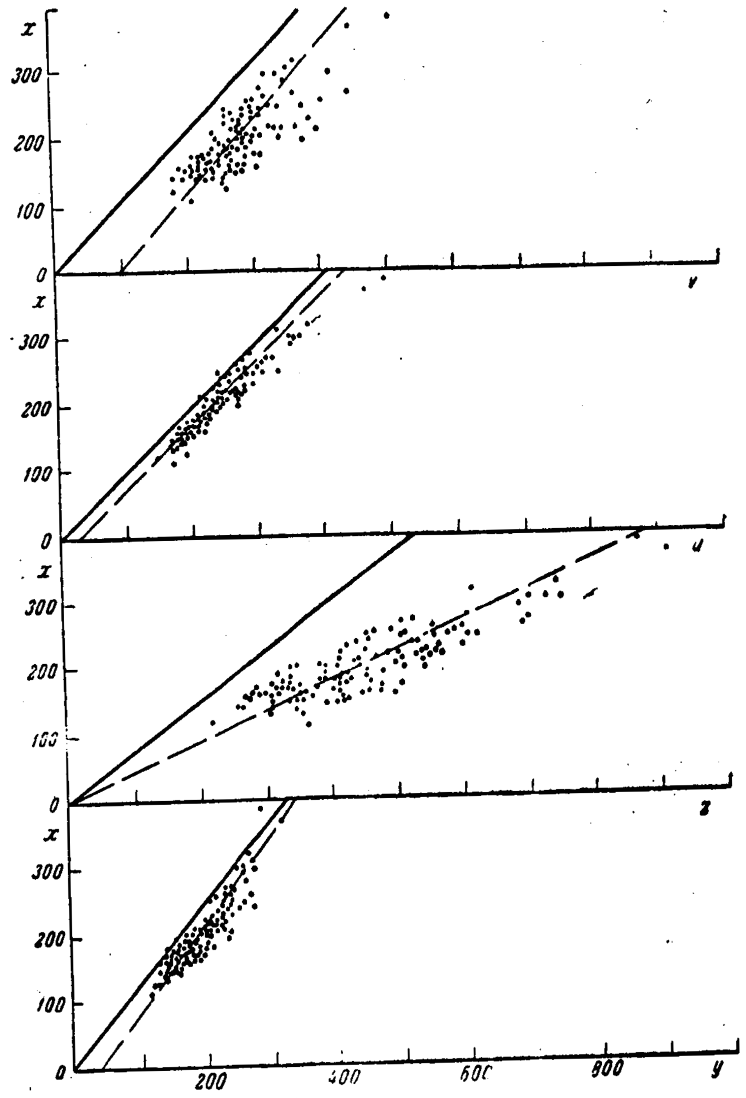

Fig. 2

(II Pole), is respectively equal to -0.045 (Table 2) and -0.109 [Table 1 in [5]), while in the first case $\sigma_{p_{yx}}=0.028$, and in the second case $\sigma_{p_{yx}}=0.015$. Besides, possible also are deflections resulting from the presence of some degree of correlation between the additional emissions with the continuum and of the former among themselves, and in particular the emission's OH (6.0) correlation at 5273 Å with OH (8.2) at 5886 Å), and also from the presence of errors of electrophotometer absolute calibration.

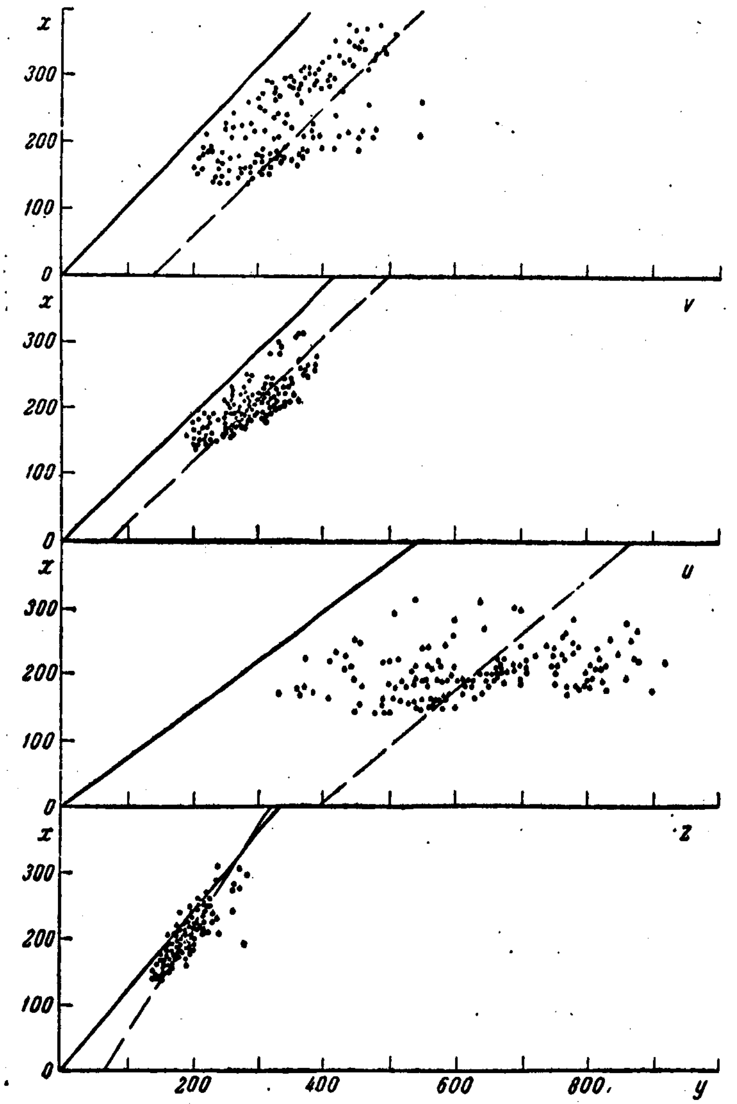

Fig. 3

According to data brought put in [5] for the dependence of night sky glow intensity w near 6300 Å on the intensity x at 5280 Å the regression coefficients p_{wx} are significantly deflected from the value corresponding to type G2 intensity distribution.

However, taking into account the low precision of the measurement in the region $\lambda = 6300$ Å, a satisfactory coincidence of the lower limit of point scattering with the line corresponding to type G2 intensity distribution can be noted.

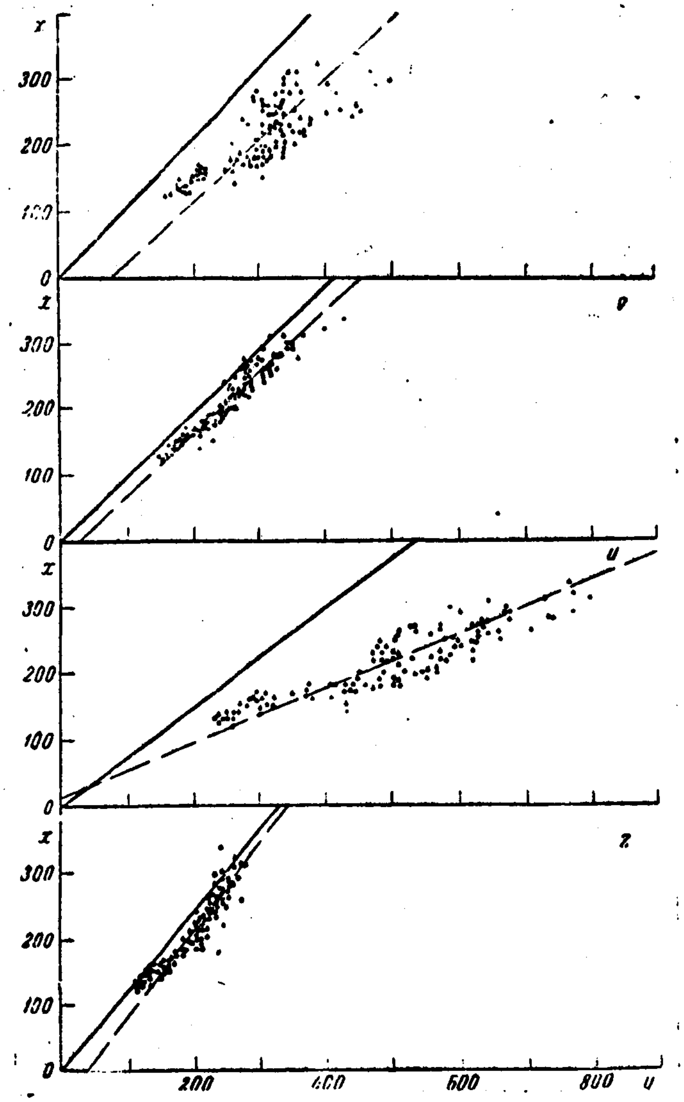

Fig. 4

Taking into account the above-indicated all sorts of errors, the observed deflections of separate and mean values of p_{yx}, p_{ux}, p_{vx} from the coefficients s, l, m (Table 2), corresponding to type G2-intensity distribution can be considered sufficiently small, i. e.

it may be estimated that they are within the bounds of method's aggregate errors. As to the cause of experimental point scattering relative to separate measurements, this question will be considered below.

In the whole, spectrographic and the Zvenigorod photoelectric mean data (Table 1) on the spectral composition of night sky emission in the continuous spectrum form a system of data, satisfactorily agreeing with one another.

b) Evidently, various interferences can manifest themselves on the quantities r, S, $S/\bar{I}$ in Table 2, and not only the variations of complementary emissions, such as [OI] 5577, NaD and others. These interferences may stem from possible variations of the terrestrial emission component's spectral composition in the continuous spectrum, and from the variations of the spectral composition of the extraterrestrial emission component in the continuous spectrum or of its intensity (in Zenith). This applies for a spectral composition distinctly different from that of class-G2 stars. They may also be connected with the measurement error of x, u, z, u, v intensities, with the error, conditioned by nonsilmultaneity of measurements with various filters, with that resulting by nonpreservation of absolute calibration and, finally with the variations of weak discrete emissions near 5280 Å.

The intensity of night sky glow in the zenith near 5280 Å was measured twice at the beginning of each hour: at the beginning and at the end of a series of measurements with 6 different filters, lasting about 2 minutes. From the comparison of these measurements one may judge that the proportion of the types (3) and (4) in S is small, whereas type (5) and type-(6) errors (the latter in the first approximation) can also be neglected, since the error (5) induces mainly an additional point scattering along the regression line.

Following Truttse [11, 12], the type-(2) errors may condition the quantity S in its entirety, or to a substantial extent. However, this conclusion is not corroborated by the results of observations in Zvenigorod.

Comparing the correlation factors r, brought out in Table 2, with the standard deflections of the estimates of S, $S/\bar{I}$, obtained through nearly simultaneous measurements at the pole (with constant intensity of the stellar component) and at the zenith (with variable intensity of the stellar component), it is possible to ascertain that the values of r for the zenith and the pole, taking into account the precision of their determination, practically coincide in all the eight cases. An analogous conclusion can be derived relative to quantities S, $S/\bar{I}$. Consequently, the type (2) errors do not manifest themselves significantly in the results of observation at zenith.

In case of ν coincidence with x, as was shown in [3, 4] (see also the discussions along this question in [10, 18, 19], involving the data from simultaneous spectrographic investigations, the main role in the formation of a standard deflection in the estimate of $S_{\nu x}$ is played by the variations of complementary emissions near 5893 Å, and not by the types (1, 2) errors. This conclusion can be simply corroborated by independent means, provided the standard deflections in the estimates S_{yx}, S_{ux} are utilized as estimate of the upper level of the standard deflection, conditioned by the possible all (1 - 6)types of interferences in the visible region of the spectrum and comparing them with the quantity $S_{\nu x}$. An analogous conclusion can be derived on the nature of S_{zx}, comparing S_{yx}, S_{ux} with S_{zx}. At the same time, when determining the variations of the intensity of the [OI] 5577 emission, the aggregate effect of all the (1-6)-types of interferences results smaller than at determination of the variations of NaD emissions.

We shall consider as an example the cases with most unfavorable ratios of $S_{\nu x}$ or S_{zx} to S_{ux}. Introducing into the value $S_{\nu x} = 60$ (I zenith) the correction for $S_{ux} = 26$ (see Table 2) taking into account the difference in values $\Delta\lambda$ near 5710 and 5893 A (where $\Delta\lambda$ is the equivalent width of photometer's pass band), we obtain that the corrected value is $S_{\nu x} = \sqrt{(60)^2 - (0,92 \cdot 26)^2} = 55$. Similarly, introducing into the value $S_{zx} = 61$ (II Pole) the correction for $S_{ux} = 16$, account being taken of the difference of $\Delta\lambda$ near 5710 and 5570 Å, we have:

$$S_{zx} = \sqrt{(61)^2 - (1,31 \cdot 16)^2} = 57.$$

c) It may be shown that the value of the coefficients q_{ux} is only partly affected by the interferences created by the [O1] 5577 and NaD emissions at measurements near 5710 A; at the same time, the residual intensity after the introduction of the respective corrections, constitutes a significant fraction of the initial values of q_{ux}. Consequently, near 5710 A as well as near 4280 A, complementary emissions are present in the continuous spectrum with intensity distribution close to that of type-G2, besides the main emissions.

d) Standard deflections y relative to the regression line y along x and the standard deflections of u relative to the regression line of u along x constitute 6 – 10% (Table 2). Let us make more precise the role of variations of complementary emissions and of the non-constancy of the spectral composition of the terrestrial radiation in the continuous spectrum. Note that in Fig. 1 – 4 the surfaces of point scatter, representing the dependence of u on x or of y on x, are shifted relative to coordinate origin along the axes u or y in such a way, that the lower limits of the scattering practically coincide with the solid lines passing through the origin of coordinates and correspond to the factors and s. It is striking, that this coincidence is practically preserved for substantial (about twofold) variations of the quantity S_{ux}. This may surely be explained by the fact, that the aggregate distance of points on account of variations of complementary emissions and of inconstancy of the spectral composition of terrestrial background, gives a quantity, corresponding to the mean intensity of complementary emissions in y or u, and at the same time, when u matches x, this compensation is not disrupted by S_{ux} variation by about a factor of 2. However, the simultaneous presence of such a compensation in various parts of the spectrum and so much the more, its preservation, is little probable. Naturally, the explanation consists in that S_{ux} and S_{yx} are mainly conditioned by the variations of complementray emissions, and the intenisty variations of the latter are attended by corresponding variations of S_{ux} (S_{yx}).

5. - In order to explain the occurrence of nightglow in the continuous spectrum and the emission NaD, the following reactions have been proposed :

$$NO + O \rightarrow NO_2 + h\nu, \qquad (1)$$

$$NaO^* + O \rightarrow Na^* + O_2. \qquad (2)$$

However, as a result of reaction (1), emission occurs mainly within the 5500 — 6500 Å range, with a maximum near 6000 Å. Inasmuch as oxygen atoms participate in reactions (1) and (2), some degree of correlation must be observed between the emission intensities in the continuous spectrum and of NaD. According to the data obtained, the intensity maximum in the continuous spectrum near 6000 Å is not observed and the emission in the continuous spectrum does not correlate with that of NaD [3].

It was established lately, that there exists a dust "shell" around the Earth, and some cases of substantial increase in the intensity of cosmic particle flux were registered [20]. However, in order to corroborate the old hypothesis on the possible role of scattered solar light, additional data are necessary. On the other hand, it should be noted that the closeness to type-G2 intensity distribution might signify simply the presence of small dependence of emission intensity in the continuous spectrum on the wavelength λ.

In conclusion, the author expresses his thanks to A. A. Kuznetsova for her help in computations.

Received on
30 May 1963

*** THE END ***

Translated by ANDRE L. BRICHANT
under Contract No. NAS-5-2078
at Consultants & Designers, Inc.
Arlington, Virginia,
15 June 1964

REFERENCES

1. RAYLEIGH. On a night sky of exceptional brightness, and on the distinction between the polar aurora and the night sky. Pros. Roy., A131, No. 817, 1931.

2. D. BARBIER et J. GLAUME. Corrélations entre les intensités de diverses radiations de la luminescence atmosphérique nocturne. Ann. Géophys., 16, No. 1, 1960.

3. V. M. MOROZOV. O nepostoyanstve fotometricheskiye danniyye, o kontinuume v svechenii nochnogo neba. Izv. AN SSSR, ser. geofiz., No. 12, 1961.

4. V. M. MOROZOV. O nepostoyanstve spektral'nogo sostava kontinuuma v svechenii nochnogo neba. Izv. AN SSSR, ser. geofiz., No. 4, 1962.

5. V. M. MOROZOV. O spektral'nom sostave peremennoy sostavlyayushchey izlucheniya v nypreryvnom spektre nochnogo neba. Astron. zh. 41, No. 2, 1964.

6. Z. V. KARYAGINA i L. N. TULENKOVA. Spektrofotometricheskoye issledovaniye nepreryvnogo i emissionnogo spektra nochnogo neba v visual'noy oblasti spektra. Izv. Astrofiz. In-ta AN KAZSSR, 9, 1959.

7. N. N. SHEFOV. Intensivnosti nekotorykh emissiy sumerechnogo i nochnogo neba. Sb. "Spektral'nyye, elektrofotometricheskiye i radiolokatsionnyye issledovaniya polyarnykh siyaniy i svecheniya nochnogo neba." No. 1, 1959.

8. N. N. SHEFOV. Intensivnosti nekotorykh emissiy nochnogo neba. Sb. "Spektral'nyye, elektrofotometricheskiye i radiolokatsionnyye issledovaniya polyarnykh siyaniy i svecheniya nochnogo neba." No. 2-3, 1960.

9. N. N. SHEFOV. Nepreryvnyy spektr v svechenii nochnogo neba. Sb. "Spektral'nyye, elecktrofotometricheskiye i radiolokatsionnyye issledovaniya polyarnykh siyaniy i svecheniya nochnogo neba. No. 5, 1961.

10. N. N. SHEFOV. Zamechaniya po povodu nekotorykh vyvodov V. M. Morzova o kontinuume v izluchenii nochnogo neba. Izv. AN SSSR, ser. geofiz., No. 12, 1961.

11. YU. L. TRUTTSE. Spektral'noye raspredeleniye vneatmosfernoy i

i atmosfernoy sostavyayushchikh kontinuuma v svecheniye nochnogo neba. Sb. "Polyarnyye siyaniya i svecheniye nochnogo neba." No. 10, 1963.

12. YU. L. TRUTTSE. Ismereniya fona pri fotoelektricheskikh nabludeniyakh emissii (ol)5577 A. Sb. "Polyarnyye siyaniya i svecheniye nochnogo neba." No. 10, 1963.

13. F. E. ROACH. Manual for photometric observations of the airglow. Instruction manual N IV aurora and airglow Pergam. Press, London, 1956.

14. A. D. BOLYUNOVA, V. M. MOROZOV. O fotoelektricheskikh ismereniyakh svecheniya nochnogo neba. Izv. AN SSSR. Ser. geofiz., No. 2, 1959.

15. V. M. MOROZOV, A. D. BOLYUNOVA, M. A. YERMOLAYEV. Ob etalonirovanii fotoelektricheskikh ismereniy slabykh istochnikov sveta. Izv. AN SSSR, ser. geofiz., No. 4, 1962.

16. V. M. MOROZOV. O vliyanii effekta rasseyaniya sveta v real'noy atmosfere na nablyudaemuyu yarkost' svecheniya nochnogo neba. Izv. AN SSSR, ser. refiz., No. 12, 1962.

17. V. M. MOROZOV. Nekotoryye osobennosti emissii (Ol)5577 i kontinuuma v svechenii nochnogo neba. Izv. AN SSSR. Ser. geofiz., No. 10, 1962.

18. V. I. KRASOVSKIY. Pis'mo v redaktsiyu. Izv. AN SSR, ser. geofiz., No. 12, 1961.

19. B. A. BAGARYATSKIY. O diskussii po povodu rezul'tatov fotoelektricheskikh izmereniy kontinuuma v svechenii nochnogo neba. Izv. AN SSSR, ser. geofiz., No. 12, 1961.

20. T. N. NAZAROVA. Issledovaniye meteornoy pyli na raketakh i iskusstvennykh sputnikakh Zemli. Sb. "Iskusstvennyye sputniki Zemli." vyp. No. 12, 1962.